Olympic Coast
National Marine Sanctuary

Side Scan Sonar Seafloor Survey

Juan de Fuca Shelf and Canyon
Washington Coast

Cruise Report
OCNMS-HMCR-104-2000-02

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1 INTRODUCTION

The Naval Undersea Warfare Center Division Keyport was contracted by the Olympic Coast national marine sanctuary (OCNMS) to conduct a side scan sonar survey on the continental shelf in the vicinity of the Juan de Fuca canyon. The purpose of this cruise was to collect side scan sonar (SSS) imagery and to field test the newly purchased QTC View vertical incidence acoustic sediment classification system which will be implemented for use in habitat characterization in the OCNMS. As well as habitat characterization, the SSS imagery will be used for control site selection for the OCNMS fiber optic cable monitoring research program. The areas surveyed during this cruise were all selected for the purpose of cable impact research site selection.

1-1 Area Surveyed

The survey area was approximately 130km^2 in size, being about 27 x 8km, roughly off-shore of Point of the Arches (Figure 1). Water depth ranged from approximately 60m to 240m.

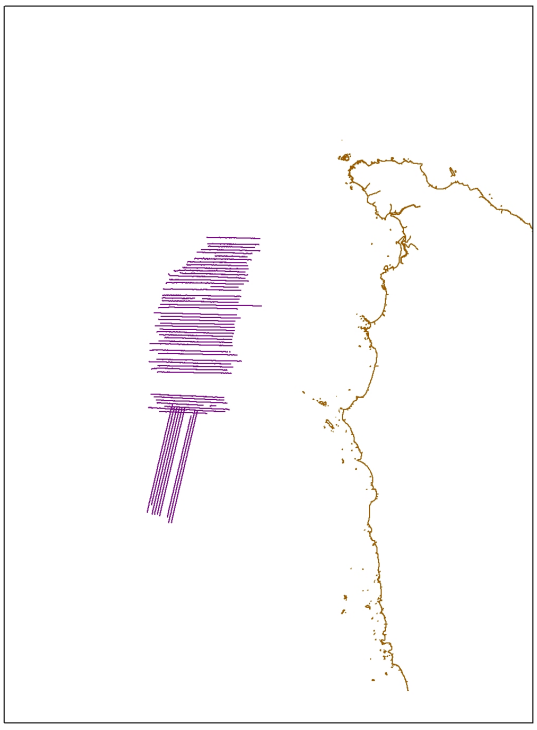

Figure 1. Location of Survey Area.

2 DATA ACQUISITION

2.1 Vessel

The 108' Navy YP 697 (Figure 2), based out of the Naval Undersea Warfare Center Division Keyport, WA, was used for the survey. Technical specifications for the vessel are located in Appendix B.

Figure 2. A YP 680 class training vessel similar to the YP697 used for this survey.

2.2 Equipment and Procedures

The Naval Undersea Warfare Center Division Keyport provided all the SSS equipment and data acquisition system, single beam data acquisition system, operators, and support equipment. The QTC View system was provided by OCNMS. The survey lines were run in an east-west fashion. The QTC View system was used concurrently with the SSS data collection so that the SSS imagery can be used as one method of calibrating the QTC View system, with hopes of systematically surveying sediment types throughout the sanctuary in the future. It is also hoped that the QTC View system can be used as a ground truth tool for the SSS imagery provided by TYCO for the area surveyed along the Pacific Crossing fiber optic cable route. Preliminary thoughts are that the QTC View will have the ability to delineate more discrete sediment types than SSS imagery alone. However, these two technologies are complimentary and might provide the greatest detail of the habitat in OCNMS.

2.2.1 Positioning

Vessel positions were determined with a differential global positioning system (DGPS). A Trimble Ag32 beacon was used (scanning for Coast Guard Amphritrite beacon). The positional

acquisition system used to control the survey was the Quality Integrated Navigational System (QINSy). QINSy records all raw sensor information and communicates the required information between sensors. QINSy was also used to log single beam vertical incidence echosounder data files. Tow fish position was measured using a Trackpoint II ultra short baseline system (USBL) and DGPS. The actual position recorded was the transponder, which was mounted approximately 2 meters forward of the DGPS beacon.

2.2.1.1 Project Datum

Positional information supplied by DGPS was in the WGS84 datum (Table 1) and all online survey was conducted using this datum. Data sets were projected to the universal transverse mercator (UTM) Zone 10 North projection (Table 2) for mapping and display. The vertical datum for the project was Mean Lower Low Water (MLLW).

Table 1. Datum Parameters

Datum	WGS84
Spheroid	WGS84
Semi-major axis	6378137.000
Semi-minor axis	6356752.314
Inverse flattening (1/f)	298.2572236
Eccentricity squared (e^2)	0.006694380

Table 2. Projection Parameters

Projection	Universal Transverse Mercator (UTM)
Zone	10 North
Unit	Meter
Latitude of Origin	0
Central Meridian (CM)	123 W
False Easting	500,000
False Northing	10,000,000
Scale Factor at CM	0.9996

2.2.2 Sounder
The single beam depth sounder on the ship was a ROSS model 875 100kHz echosounder.

2.2.3 Side Scan Sonar
The survey was conducted with a DOWTY dual frequency SSS tow fish. Backscatter was logged to a Triton-Elics International ISIS data acquisition system in XTF format.

2.2.4 Acoustic Sediment Classification
For collection of the acoustic sediment classification data, a separate data acquisition system was installed which included a QTC View (Series 4) box, and an Knudsen 320B echosounder with a narrow beam 50 kHz Ross transducer. An data processing system was also installed on the vessel for real time processing to verify the quality of incoming data.

2.3 Data Quality
The execution of field operations was not as efficient as a NOAA vessel but was acceptable. This was to be expected since the crew and technicians are not used to working with each other year round as is the case on NOAA vessels. The SSS imagery was of relatively poor quality. The technicians unfamiliarity with the data acquisition system did cause loss of production and bad data collection. The unfamiliarity appears to be a result of the system being fairly new, thus the technicians did not have sufficient time to learn the system. Sonar navigation data was especially noisy in deep water, primarily due to the type of receiver used in the Trackpoint II system. The Trackpoint II system uses a downward looking receiver, where an aft looking receiver would be more appropriate for deep-water tows, unless a depressor is used. The ship itself was apparently designed to be a training vessel and purposely handles like a destroyer, thus there was also excessive roll.

Initial results from QTC View identified several issues for future consideration. First, significant com port communication problems were encountered. It is believed the problems encountered were primarily due to the poor com port management by the windows operating system. Furthermore, it was found that the high efficiency of the narrow beam (7.5 degree) 50 kHz transducer worked exceptionally well with the Knudsen 320B echosounder, and tracked the bottom even with low power in the mid-depth ranges of the survey area. However, with the high efficiency transducer, the return signal was very strong making it necessary to attenuate the received echo much more than normal for acoustic sediment classification to avoid clipping returns. In the shallower areas of the sanctuary this transducer will not be appropriate, and a wider beam/less efficient transducer will have to be used for sediment classification. The QTC view acoustic sediment classification data collected on the first half of the cruise was collected with one attenuator and is not usable and will have to be rejected. With the narrow beam transducer, the roll of the vessel and the sweep of the beam footprint becomes a significant issue.

3 DATA PROCESSING

3.1 Positioning

Due to the poor performance of the Trackpoint II system, the positioning of the tow fish had to be smoothed using a two-pass Kalman filter technique. The filtering routine was done by Dr. Semme Dijkstra, Center for Coastal & Ocean Mapping, University of New Hampshire.

3.2 Backscatter

All backscatter was processed using Triton Elics Isis Sonar on a Windows workstation. A full beam angle compensation (bac) curve was calculated for each line and custom TVG curves were also applied during mosaicing. Since no cable out data were recorded, the USBL positioning provided the only source of tow fish positioning for the backscatter. Mosaics were exported at 1m resolution.

3.3 Texture Analysis

Several studies (Skohr 1991; Blondel 1996) have found the use of grey level alone for assigning classification codes to side scan sonar imagery as being inadequate. Thus a co-occurrence matrix approach was instead used as a preferred alternative for classifying the imagery, since it has been found too more effectively assess the spatial relationship of pixel intensities from remote sensing data (Haralick 1973; Blondel 1996). An image classification routine was performed on the mosaiced 1m image through the use of an automated image analysis routine that uses entropy and homogeneity textural indices (Cochrane 2002). Other studies (Blondel 1996) have successfully used entropy and homogeneity indices to effectively classify side scan sonar data, thus these indices were chosen for texturally classifying the imagery in this study.

Binary code for the texture analysis procedure was obtained from the USGS (Cochrane 2002) and compiled in Linux Mandrake 9.1. The initial procedure involved running the binary program *TexScal*. This first step calculated the range of values for entropy and homogeneity and assigned correction values that rescaled floating point values to 8-bit numbers within a range of 0-255, to be on a similar scale as the data from the raw side scan imagery. Next, the program *TexGen* was executed to create the entropy and homogeneity textural index images. *TexGen* accepts both the range and scaling factors for the homogeneity and entropy indexes that were calculated during the *TexScal* procedure. Textural signatures were then selected for training the classification program by using Erdas Imagine to visually locate individual signatures for each of the sediment types. Map coordinates for pixels from a 15x15 bounding box (for soft sediment) and 5x5 bounding box for rocks were used as training signatures and were entered into the program *TexSig*. *TexSig* takes the map coordinates and locates the grey scale values at each pixel location from the entropy, homogeneity, and side scan images, to create the final classification signatures for input into *TexClass*. *TexClass* was then executed which used the signatures files created in *TexSig* to create a thematic grey scale image from the three continuous grey scale images (homogeneity index, entropy index, and the raw side scan image) which represented the classified image. This procedure was run three separate times to create individual classification images for each sediment type (sand_silt_clay, coarse_mixed_sediment, and rock_boulder) that

was visually observed in the side scan imagery. Adobe Photoshop was used to visually remove data that was determined to misclassified or to to remove null data for each class. The mosaic feature in Erdas Imagine was then used to merge the three edited thematic images into one final image. ArcInfo was used to convert the raster image to a polygon feature class.

3.4 Acoustic Sediment Classification

The QTC View data were saved as preliminary FFV and CAL files. Processing was not undertaken due to poor performance in the data acquisition.

4 CHARTING AND DATA PRODUCTS

Charting was carried out using ESRI ArcGIS 9.0 software to display chart backgrounds, legends, and overlays of all vector data layers.

5 RESULTS

5.1 Texture Analysis

The seafloor in this area consists primarily of fine-grained sand and silt along with clay. Ground truthing was conducted through use of a ship deployed Smith-Mac grab sampler using data from the 2000 OCNMS research cruise, 2000 OCNMS fiber-optics monitoring cruise, and the 2001 OCNMS fiber-optics monitoring cruise.

Table 3. Summary Image Classification Results.

Sediment	Area_km^2	Percent Cover
Sand	116.96	90.3486
Coarse Mix	12.46	09.6315
Rock	0.02	00.0001

Appendix A. Daily Log Events

Wed July 5; Finalize the installation of acquisition systems. The bracket for mounting the 50 kHz transducer had to be modified by Keyport personnel because the NOAA supplied transducer did not have the designed bolt pattern. All other installations went as planned.

Thu July 6; The vessel departed Bangor submarine base at 0600 for the Sanctuary. During transit final survey planning was completed and acquisition systems were prepared for the survey area. Arrived at the Sanctuary boundary approximately 1800. Initial QTC View calibrations were conducted. The initial calibration indicated the high efficiency transducer made collection acceptable data difficult. The planned survey line out the fiber optic cable route was postponed and the Agate Passage transited to the priority survey area 1.

Fri July 7; A sound velocity cast was conducted and sss survey operations begun. Once on site it was found that the QINSy survey system was not operational. While the QUINSy system was being worked on we began various tests using the QTC View system. In addition we occupied/collected data at unique sites picked from the historical sediment maps and several Lie locations were we have previously collected sediment samples.

Sat July 8; Data collection at the unique sample sites were completed. The depths sampled with the QTC View system ranged from 50 meters to 350 meters. It was determined that indeed the QTC View system with the Ross 50kHz transducer could not acquire usable data in those shallow water depths. In discussions with QTC it was determined that a second attenuator could be placed in line thus attenuating the return signal by 40 db. The QUINSy system was made operational and SSS operations commenced. After a few survey lines were completed in priority area 1 the SSS winch control broke and the towfish fins were lost. A larger 500 lb depressor was tried on the towfish cable but immediately aborted due to excessive vibration, standing waves, in the tow cable that showed up as noise in the imagery. A 250 lb depressor was used throughout the survey operations. The first several survey lines were processed and a towfish-positioning problem was identified. QINSy was configured to send ships position as towfish position to the ISIS sss system. The winch was repaired, the correct navigation parameters were entered into the acquisition system and sss operations continued. The first couple lines after switching navigation parameters were processed and it was found that although the correct navigation was recorded it was extremely noisy. It is not usable as is but will need a navigation filter to smooth the data.

Sun July 9; Continued sss operations in priority area 1. It was determined that Triton ISIS could supply a software program for correcting the navigation in the earlier SSS survey lines. It was also arranged to have QTC FEDEX an attenuator to the USCG in Neah Bay. Pole holding the QINSy/Ross 100kHz transducer broke. Continued sss operations without recording sounding data. QTC View sounding data can also be used.

Mon July 10; Continued sss operations on priority area 1. A second sound velocity cast was conducted and found no significant change in the water column. Intermittent communication

problems were becoming more prevalent in the QTC View data acquisition system. Discussed communications difficulties with Knudsen Engineering and we determined it was likely due to com port conflicts in the acquisition computer. Knudsen would email a more stable terminal program for testing com ports.
Broke off SSS main scheme survey lines and conducted a survey line crossing the survey lines already completed as a crosscheck for positioning issues. Conducted a sss line down the axis of the Juan De Fuca Canyon and over several lie points for visual verification of sediment samples previously collected at the lie stations.

Tue July 11; Broke off all survey operations at 0900 and transited to Neah Bay. The Agate Passage took on additional provisions. The 100kHz transducer pole was repaired. The navigation stripping utility was received from Triton ISIS, the terminal program was received from Knudsen, and the attenuator was received from QTC. The Agate Passage got under way at approximately 1500. The attenuator was installed and calibration of the QTC was conducted with 40db of attenuation. Acceptable settings were found and we begun a QTC survey line parallel to the fiber optic cable route.

Wed July 12; Most of the QTC survey lines parallel to the fiber optic cable route was completed and a sound velocity cast done. Agate Passage then transited to priority area 3 the shallow area off of Cape Alava. On the second long survey line the towfish snagged a crab pot and tore the towfish cable. The towfish cable had to be re-terminated. In the interim we conducted additional tests with the QTC View system in shallow water and found that even with 40 db attenuation collecting usable shallow water data is difficult at best because of the high efficiency of the 50kHz transducer. Due to loss of daylight, a high density of crab pots when the sss system was operational we surveyed our way out to priority area 2 collecting data over several more Lie sample locations.

Thu July 13; Begin survey of priority area 2. The seas picked up and there was a swell of approximately 3 to 4 feet. The roll of the Agate Passage required the survey lines be reoriented so the ship was moving with or into the seas. What appears to be an unidentified, probably DOD, cable was found.

Fri July 14; Continue to survey in priority area 2, break off at 2200 conduct a sound velocity cast and transit to first set of fish block reconnaissance survey lines.

Sat July 15; Conduct reconnaissance survey lines in NMFS fish block 1420, 1419, 1418, 1417.

Sun July 16; Complete reconnaissance survey lines and verified existence and location of a wreck approximately 300' long lying in an east-west direction in approximately 240 meters of water. 0400 Broke off survey operations and transited to Bangor. Arrived K/B docks at Bangor approximately 1500. OCNMS equipment was dismantled and removed from the ship ending the field operations.

Appendix B. Vessel Specifications

YP 697 Vessel Specifications
Builders: Marinette Marine
Power Plant: 12V-71N Detroit diesel engines
2 propellers
horsepower rating 437 shaft horsepower @ 2,100 RPM
Overall Length: 108 feet (32.9 meters)
Waterline Length: 102 feet (31.1 meters)
Beam:24 feet (7.3 meters)
Draft: 8 feet (1.9 meters)
Speed: 12 knots (19.6 km/hr)
Cruising Radius 1800 nautical miles (3300 km)
Hull Material: Wood hull, aluminum superstructure.
Crew: Officers: 2 Enlisted: 4
Safe capacity: 50 people

Appendix C. Vessel Offsets for Sensors

1. Ross/QINSy Sounder for single beam (from RP)
   X= -3.81
   Y= -6.55
   Z= 3.58

2. Trackpoint II (from RP)
   X= -3.71
   Y= -9.75

3. Ag32 DGPS Positioning (from RP)
   X= -1.93
   Y= -4.27
   Z= -6.65

4. TSS DMS05
   X= 0.00
   Y= 4.11
   Z= 0.00

Appendix D. Survey Effort
Linear kilometers surveyed – 227.53
Area (km2) surveyed -- 421.42
Total Sonar Acquisition Time – 68:31:32

Personnel
Rick Fletcher, OCNMS, Project Manager
Semme Dijkstra, Acoustic Sediment Classification Technical Assistance, Position Filtering